



## 2.0 Methodology

The methodology used to complete these studies is outlined below:

- The California State Fire Marshall, Pipeline Safety Division contracted EDM Services, Inc. to conduct the pipeline studies.
- A Preliminary Questionnaire, requesting detailed pipeline system information, was sent to each pipeline operator. The information requested for *each pipeline unit* included: 1) the accuracy, consistency and availability of in-house leak records; 2) a complete description of each pipeline system, including operational information and pipe inventory; 3) the dates of all hydrostatic tests and cathodic protection surveys; 4) the extent of preventative maintenance performed; 5) leak detection system information; 6) block valve spacing information; etc.
- The pipeline operators forwarded completed Preliminary Questionnaires to EDM Services offices. They were used to verify the pipeline inventory, leak data and other information. This system of verification was intended to assure the greatest possible degree of accuracy and reliability of the results reported herein.
- Leak incident data were personally collected from each pipeline operator by an EDM Services representative. During the field visit to the various pipeline operator offices, in-house leak records were audited and information from them was verified and augmented to the fullest extent possible. It should be noted that *all recorded leaks that occurred on regulated pipelines were included in the study*, even if they did not create enough damage or meet other state and/or federal reporting requirements.
- The raw data collected was initially input using Lotus 123. It was subsequently downloaded and analyzed using the SAS statistical software package.

The following subsections 2.1 through 2.10 provide more descriptive information about the detailed steps taken to accomplish each study task. Unless specific, detailed information regarding this methodology is desired, the reader may skip from here, directly to Section 3.0 of this report.

### 2.1 Contracting

On August 23, 1990 the California State Fire Marshal's office released a request for proposals to conduct two studies. Completed proposals were received by October 12, 1990. The proposals were reviewed and evaluated using a point system as follows:



- 30 Points - Response to Requirements
- 30 Points - Experience and Expertise
- 10 Points - Quality of Proposal Presentation
- 30 Points - Cost Evaluation

Once the proposals had been evaluated and ranked, the top few bidders made oral presentations. An additional 30 points were awarded based on these presentations. The contract was awarded to the highest scoring bidder meeting the State's minority and woman owned business subcontracting requirements, EDM Services.

The final contract was approved on March 6, 1991. The contractual work scope is summarized below:

- identify jurisdictional pipelines located within 500 feet of any rail line,
- identify the geographic location of those pipelines determined above as to urban or rural,
- identify the leak-history of all jurisdictional pipelines and classify as to their location within or outside a 500 foot zone along rail lines, urban, rural, and environmentally sensitive areas,
- analyze historical events for damage to pipelines from derailments,
- identify and analyze the impact of geological or seismic activities on all jurisdictional pipelines,
- analyze the feasibility of testing, repair, replacement and/or relocating pipelines suspected of potential damage resulting from a railroad derailment,
- analyze the feasibility of pipeline operators notifying local affected fire agencies of the contents and any changes in the hazardous liquid being transported, and
- evaluate the best control technology available to protect public safety in the event of a pipeline emergency resulting from a railroad derailment.

The contract *deliverables* were to include the:

- collection, compilation, and analysis of all data,
- characterization of risk levels associated with pipelines in general,
- characterization of risk levels associated with pipelines located within 500 feet of rail lines, and



preparation of a report based upon the above analyses.

## 2.2 Pipeline Operator Notification

On April 4, 1991, Mr. James Wait, Division Chief, Pipeline Safety Division, California State Fire Marshal, notified all of the regulated hazardous liquid pipeline operators of the studies being performed by EDM Services. This was done via a letter from Mr. Wait to each of the operators. The notification letter included the following:

- a brief description of the Assembly and Senate bills requiring the studies,
- a statement that the CSFM intended to use the study results to generate a Legislature Report and develop regulations governing the construction, testing, operation, periodic inspection, and emergency operations of hazardous liquid pipelines,
- notification that EDM Services personnel would be visiting each pipeline operator to collect specific leak data, and
- notification that EDM Services would be forwarding questionnaires to each operator soliciting information regarding leak records, pipeline system information, etc.

## 2.3 Key Contact List and Preliminary Questionnaire

On April 26, 1991 EDM Services forwarded a Preliminary Questionnaire, Key Contact List, and detailed instructions for their completion to each pipeline operator. The Key Contact List was used by each pipeline operating company to identify a key contact(s) within their organization to coordinate the California State Fire Marshal's pipeline safety studies. The Key Contacts for most of the pipeline operators were responsible for the following activities:

- completing and returning the Key Contact List,
- completing and returning the Preliminary Questionnaire, and
- working with EDM Services' field personnel during their visit and review of leak records, alignment sheets, etc.

The completed Key Contact Lists were scheduled to be returned to our office by May 10, 1991. Unfortunately however, many of the forms were several months late.



The Preliminary Questionnaire was comprised of two parts (A and B). Part A was used by our firm to plan and schedule the review of each operating company's leak reports and alignment sheets. It covered general information such as the location(s) of leak records, potential differences in record keeping procedures for interstate versus intrastate lines, criteria for recording leaks in rural versus urban areas, and any changes which may have taken place in the criteria used to record leaks during the study period.

Part B provided very detailed information regarding each pipeline system. Combined with the leak data collected during our field visits, this data was the cornerstone of the studies. As a result, the importance of accurate information was emphasized. Since the data requested was fairly exhaustive, it was anticipated that it would require a significant effort on each operators part to compile.

The Preliminary Questionnaire - Part A's were scheduled to be completed and returned to our office by Friday, May 17th. The Preliminary Questionnaire - Part B's were scheduled to be completed and returned to our office by Friday, May 31st, or upon our visit to each operator's office, whichever was sooner. Unfortunately however, the final completed questionnaires were not received until April 1992, nearly a year late.

## 2.4 In-House Mapping and Background Information

Prior to gathering the actual leak data during our field visits with each operator, it was necessary to gather a significant amount of background information. These tasks included:

- a. Securing a mailing list from the CSFM identifying the initial contacts and addresses of the pipeline operators.
- b. Obtaining the CSFM's list of high risk pipelines.
- c. Determining the total length of regulated pipeline, the total length within 500' of a rail line, and the total length of pipeline within each County. This was accomplished as follows:
  - A complete set of the CSFM's Thomas Brothers map book overlays was secured.
  - The overlays were reviewed to ensure that the set was complete. Missing overlays were requested from the CSFM.
  - A second *working set* of overlays was made.
  - Drawings showing the main rail lines in the state were secured from the Public Utilities Commission.



- The main rail lines were highlighted in the Thomas Brothers map books on all pages which also had regulated pipelines.
  - Each overlay was reviewed and the total pipe length was measured using a planimeter. The length within 500' of a rail line and the length within each County was also measured using a planimeter. The measured lengths for each pipe system were recorded on separate forms, by Thomas Guide page number and county. This data, although subject to some error because of the scale limitation, provided a check for the data received from the pipeline operators.
- d. The lengths of pipelines and lengths of pipelines within 500' of rail lines were determined for areas within and outside standard metropolitan statistical areas (SMSA). Since SMSA boundaries, as well as the data gathered in item "c" above, both coincide with county lines, this was relatively easily accomplished. The following table lists the SMSA counties, as well as those which are not SMSA's.

SMSA

Alameda  
Butte  
Contra Costa  
Fresno  
Kern  
Los Angeles  
Marin  
Monterey  
Napa  
Orange  
Placer  
Sacramento  
San Diego  
San Francisco  
San Joaquin  
San Mateo  
Santa Barbara  
Santa Cruz  
Shasta  
Solano  
Sonoma  
Stanislaus  
Sutter  
Tulare  
Ventura

Non-SMSA

Alpine  
Amador  
Calaveras  
Colusa  
Del Norte  
El Dorado  
Glenn  
Humboldt  
Imperial  
Inyo  
Kings  
Lake  
Lassen  
Madera  
Mariposa  
Merced  
Mendocino  
Modoc  
Mono  
Nevada  
Plumas  
Riverside  
San Benito  
San Bernardino  
San Luis Obispo



Yolo  
Yuba

Sierra  
Siskiyou  
Tehama  
Trinity  
Tuolumne

## 2.5 Data Gathering Guideline

As specific information became available regarding each pipeline system via the Preliminary Questionnaire - Parts A and B, EDM Services personnel were scheduled to visit each pipeline operator. Their primary objectives were to review the Preliminary Questionnaires with the operator and gather specific leak data for *all* leaks which occurred during the study period. To ensure consistency between the leak data collected and to communicate our staff's work plans with each pipeline operator, a Data Gathering Guideline was written.

This plan was intended to provide written instructions and guidelines for EDM Services' employees. It outlined the firm's intended methodology and provided specific instructions for collecting pipeline leak data. In addition, it gave pipeline operators an indication of what we would be collecting, how we intended to go about collecting it, and what level of involvement would be required from them.

Naturally, the delay in the operators' completion of the Preliminary Questionnaire - Parts A and B, significantly affected EDM Services' schedule for visiting each pipeline operator. Some of this work was delayed for nearly a year beyond the original schedule.

## 2.6 Gather Railroad and Public Utilities Commission Data

Since one of the primary study goals was to ascertain the relative risk level of pipelines near railroads versus those outside railroad areas. It was necessary to gather data regarding train derailments. This was accomplished as follows:

- Train derailment information was obtained from the Public Utilities Commission and National Transportation Safety Board for the period from January 1, 1981 through December 31, 1990.
- The accident reports were reviewed to determine the cause of derailment, extent of pipeline damage, and the type of rail line.



## 2.7 Conduct Pilot Surveys

A few pipeline operators were selected to participate in a pilot survey. This phase was intended to give us an opportunity to refine our general approach, forms and procedures early in the study. The selected operators were notified two to three weeks before our scheduled field visit. This task proceeded as described below:

### a. Arrange Visit

The field visits with the selected pilot study participants were handled as follows:

- The operators were notified that they had been selected to participate in the pilot study.
- EDM Services staff worked with the selected operators to expedite completion of their Key Contact List and Preliminary Questionnaires.
- Field visits were scheduled to coincide with the operators' completion of their Preliminary Questionnaires.
- Key Contacts were confirmed to be available to help our staff review the operating company's leak records, alignment sheets, etc.

### b. Review Key Contact List and Preliminary Questionnaire Responses

Prior to the field visit, these documents were reviewed. This review included:

- The Key Contact Lists were reviewed for completeness. We ensured that each operating company had completed a separate list for each CSFM Inspection Unit Number. We also verified that all of the regulated pipeline systems had been assigned to a key contact.

#### • Preliminary Questionnaire - Part A

The returned forms were reviewed for completeness. We ensured that separate questionnaires had been completed for each CSFM Inspection Unit Number. We also verified that leak record storage locations had been provided for each of the regulated pipeline systems.



• Preliminary Questionnaire - Part B

These forms were reviewed for completeness. We ensured that separate questionnaires had been completed for each regulated pipeline system. Any incomplete responses were referred to the company's key contact. The total pipeline length, and the length of line within 500' of a rail line were checked against our in-house data which was obtained as outlined earlier.

c. Visit Pilot Operating Companies

An EDM technician and principal visited each selected pilot operating company. The visits proceeded as follows:

- Any outstanding questions from the Preliminary Questionnaires were resolved.
- We provided an overview of the data we wished to collect and the methods we planned to use.
- We reviewed the operating company's leak records for the study period. A separate Leak Data Form was completed for each leak reviewed. Alignment sheets, cathodic protection surveys, hydrostatic tests, and other records were reviewed as necessary to properly complete the Leak Data Forms. As a result, it was necessary to work with an operating company representative to gather all of the necessary data.

d. Evaluate and Refine Data Collection Guideline

Based on our experience with the pilot operating companies, the Data Collection Guideline was revised as necessary.

**2.8 Gather Data From Remaining Operating Companies**

After the pilot study had been conducted and as completed Preliminary Questionnaires were received, visits were scheduled with each of the operating companies. This work proceeded as discussed earlier for the pilot operating companies.





## 2.9 Statistical Analysis

The raw data collected were initially entered using Lotus 123. They were subsequently downloaded and analyzed using the SAS and STATA statistical software packages. Descriptive statistics were performed using incident rate units of *incidents per 1,000 mile years*. These incident rates were determined by dividing the number of incidents by the number of mile years of pipeline operation for a given category of data. Thus for all pipelines built before the commencement of the study, which continued in operation through the study period, the number of mile years was determined by multiplying the pipe length by the ten year study period. For pipelines built sometime during the study period, the number of mile years was determined by multiplying the pipeline length by the actual number of years of operation during the study period.

The dichotomous probability of an incident occurring was determined using logistic regression analysis. We controlled for various factors, such as pipe age, to determine the independent effects of variables on the probability of a leak incident. The independent variables considered included operating temperature and flow, operating pressure, type of cathodic protection system, interstate versus intrastate pipeline, etc.

## 2.10 Potential Data Inconsistencies

The importance of an accurate pipeline inventory on the study results can't be overemphasized; the inventory data directly affects the calculated incident rates since it is used in the denominator of the incident rate equation. For example, a ten percent error in the pipeline inventory alone would result in a corresponding ten percent error in the calculated incident rate. As a result, a laborious mapping effort was undertaken to verify the data furnished by the pipeline operators on their Preliminary Questionnaires. (See also Section 2.4 presented earlier for a detailed description of this methodology.)

The pipeline inventory data gathered through EDM Services' mapping effort was then compared with the data furnished by each pipeline operator, for every pipeline included in the study. Finally, a significant effort was undertaken to resolve the inherent discrepancies between the mapped data and the information furnished by the operators. Once completed, the total pipeline length information was resolved to within 0.0%. The length of pipeline within 500' of a rail line was resolved to within 1.7%. These values are much smaller than originally anticipated.

Since the reporting criteria for leaks on interstate and intrastate pipelines varied during the study period, we were concerned that the operators' criteria for keeping leak records may have varied as well. This would have caused significant problems during data analysis. For example, if the criteria for keeping leak records became more stringent during the study period, the resulting data would have falsely indicated that the actual leak incident rates were increasing.



However, we found that with only one exception, all operators had kept records on nearly every leak which had occurred on their lines, regardless of size or severity. Most operators pointed out that this practice had become necessary to enable them to successfully defend claims against them for generating contaminated soil near their pipelines.

An unavoidable limitation of the data included:

- leaks reported on pipeline units which were not functioning when we collected pipeline and/or leak data and
- leaks which occurred on pipe segments which had been replaced during the study period.

As a result, the general information parameters such as fluid contents, pipe length, operating temperature, operating pressure, diameter, and other factors used to calculate incident rates and generate statistically reliable results were unavailable for some of the original pipe segments where the leak occurred. Data regarding the original pipe where the leak occurred was restricted in these cases to that which existed on the operator's leak record. Obviously, statistical analyses in these instances are limited and we believe that any resulting errors or uncertainties are relatively insignificant.

Since the record keeping practices for leaks which occurred during hydrostatic testing were inconsistent between pipeline operators, all leaks that occurred during hydrostatic testing were deleted from the analyses. Additionally, information from one pipeline operator was completely deleted from the study after we determined that its records did not meet our standards of accuracy.